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BIOMEDICAL INSTRUMENTATION FOR MAN IN SPACE

"Present State and Potential of  
Biomedical Instrumentation"

by

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The use of advanced electronic equipment for data sensing, computation, display, and in some cases therapy, is becoming increasingly important to the medical profession. In the field of computers alone, a wide range of potential applications is now under consideration. Some of these are outlined in the staff reports of the Systems Development Corporation.<sup>1,2</sup> Schwichtenberg of the Lovelace Foundation has made preliminary applications toward the utilization of such computers for data storage retrieval and correlation;<sup>3</sup> Syner has used computers in measurements of respiratory gas exchange;<sup>4</sup> Podolsky and Shapiro in studying mechanisms of muscular contraction;<sup>5</sup> Cady in dimensions of coronary heart disease;<sup>6</sup> and Swenson has studied computers relating to storing and interpretation of personality tests.<sup>7</sup>

It can thus be seen that effort in advanced electronics has the potential of providing a generalized biomedical tool which can simultaneously increase the effectiveness of the bioscientist in research

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and reduce the waste of his time in the performance of boring repetitive tasks. Consideration of the man-machine system (Figure 1) has been the basis of significant gains in electronic equipment for linking men to both directly-controlled and remotely-controlled machine systems.<sup>8</sup>

Equipment designed within the requirements framework of such a system has permitted a human operator to improve both his short-term control capability and his long-term decision-making capability to the significant betterment of over-all man-machine effectiveness. A brief consideration of some of the components developed for this type of man-machine system might be useful in visualizing the potential of these gains to better improve the data linkage of a medical scientist with an experiment or a subject under observation.

Figure 1, a diagrammatic man-machine system, was developed to show the functional relationship between a human operator and the data collection, computation, amplification, control and display equipment needed to link him adequately to a machine. Figure 2 is a variation of the same diagram indicating that with the addition of suitable telemetering links, the human operator can effectively control a machine from a remote position provided adequate data and controls are made available to him. A wide variety of equipment development has been stimulated by working with these systems. A single example of progress in each of the major system blocks may help to illustrate the potentials.

Figure 3 is a temperature sensing device consisting of a micro-

thin film of temperature sensitive material deposited on a dielectric cylinder and protected with a similarly thin dielectric film. Because the mass of the sensing material can be made very small compared to its surface area, very rapid response to changes in temperature is possible. This type of device is useful over a wide enough temperature range to be suitable both for measuring liquid gas temperatures and temperatures of the products of combustion in a jet aircraft engine.

Figure 4 is a computer under development using thin films of magnetic material, "microcircuit" amplifiers, and solid state power supplies. A computer using these techniques might well handle up to 80 million bits of information per second and still be capable of fitting into a volume on the order of 1/4 cubic foot. Figure 5 is a thin cathode ray tube capable of producing television-like pictures bright enough to be viewed in an ambient light level of 1,000 foot lamberts. This display tube is also transparent as can be seen by viewing the calendar through it.

Figure 6 is a manual control handle configured to the natural grip of the human hand and capable of transmitting and receiving motion signals in six distinct modes plus providing three switch input potentials.

Figure 7 is a diagram showing composite improvement in reliability, complexity, cost, and capability of electronic devices achieved and potentially achievable by placing functional materials in direct contact with each other to progressively reduce the components and finally,

circuit complexity itself.

Vigorous joint efforts between physical scientists and life scientists can provide similar electronic aids systems for improved scientific observation of both direct and remote biological experiments and for better linking information from a patient to the doctor's thinking capability. Figure 8 illustrates a potential biological man-machine system by which such a linkage can be achieved. It is further readily apparent that with suitable telemetering links, the bioscientist can also make effective remote observations and provide return control signals to his remote experiment.

In addition to better linking the bioscientist to his experiment or subject, data sensed by the use of electromagnetic or other energies outside the perceiving range of human senses can provide improved inputs to such a system. One important tool in this area is the low dosage X-ray machine which is coupled with a high fidelity light amplifier to allow direct observation of internal body changes with low dosage X-rays not amenable to direct human perception or even to direct photography. New sound pickups can detect sounds at frequencies both above and below the detection range of the human ear and at intensities far below those directly accessible by the human ear. For example, very little of the sound energy from heart action is directly accessible to the human ear (Figure 9). Displays from such data can be made either audible or visible, thus providing new potentials for sensing.

The computers can configure these data to a form directly assimilable by a human operator. Recent applications of these principles have provided direct read-outs on certain heart conditions from composite ekg and sound signals.<sup>9</sup> Figure 10 illustrates a tiny electronic data sensor amplifier transmitter device capable, depending on the sensing attachment, of sensing either ekg or sound signals and transmitting them to a local receiver for telemetering to a remote station. These devices can operate with a minimum of annoyance to the subject.

Properly linked electronic machine system aids can be used to extract new information to improve the retrieval of stored data and to make reliable comparisons with existing knowledge. The resultant data can be displayed to the doctor or bioscientist in a form configured to his desired use of the information. These doctor/patient systems can improve the effectiveness of remote observations for the space bioscientist as well as being an important aid to the earth doctor.

It must, none the less, be recognized that these electronic systems should be considered as essentially "stupid" tools capable of performing only those functions for which they have been precisely designed and programmed to perform. The quality of the output, then, is a direct function of the quality of the research data upon which their designs and programs are based.

Utilization of these systems can make available large amounts of new data. Over-all effectiveness is still dependent upon the quality and brain power of the scientists or doctors utilizing the aids.

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